Developing Computation

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presents the results of a state project coordinated by the Department of Education, the Catholic Education Office and the Association of Independent Schools of Tasmania. The project focussed on the effect of developing informal written computation processes through Years 2-4. Special thanks to Denise Neal for her work in the preparation of this report.

The *Developing computation* project was conducted in Tasmania over the two years 2002–2003 and involved nine schools: five government schools, two Catholic schools and two independent schools. All Years 2, 3 and 4 teachers (a total of thirty-seven teachers) in the project schools were involved.

The objectives of this project were to:

- investigate the effect of developing informal written computation processes through Years 2 to 4 on student performance, student attitudes to computation, teacher attitudes to computation, and teacher attitudes to classroom assessment of computation; and
- determine which classroom strategies and approaches for the encouragement of informal written computation are most effective in developing students' number sense and computational ability and to analyse and explicate critical features of these approaches.

The earlier stages of the project concentrated only on mental computation. Although this appeared to leave relatively little time for the central purpose of the project, which was to look at the development of 'informal written computation', this long and deliberate introduction was critical, both for children and teachers. Since the purpose of the project was to observe the process of working on informal written computation with children who have developed strategies for calculating mentally and have a certain level of competence, it was clearly necessary first to concentrate on developing children's mental computation ability.

The project asked teachers to adopt an approach that was radically different from the traditional approach to computation in at least three fundamental aspects. First, at least as much attention was to be given to children's mental computation of two digit numbers as to single digit computation. Second, the approach was to emphasise not memorisation of individual facts, but the children's invented or informal strategies for computing the calculations mentally, and their

shared oral explanations of their strategies. Third, when numbers became larger than could be dealt with mentally, instead of learning from the teacher one standard computation method which is both alien to children's natural computation processes and unconnected with their mental methods, children would build on the mental strategies they were using and develop ways of extending these by the use of pencil and paper.

The project raised quite new and potentially threatening aspects for teachers (and indeed was the reason why several schools who were approached originally to join the project, declined to do so). First, it asked teachers to explore 'informal written computation' (a term which it would be fair to say would have been quite unfamiliar to most before the project), and to withhold the teaching of formal written algorithms, a practice which most, if not all, teachers would have considered central to their mathematics program.

A six-step process for developing informal written computation

Teachers were generally satisfied with the tangible improvements in competence and attitude resulting from the greater concentration on mental computation. They were in many cases aware from their own previous experience that the traditional approach to teaching standard written algorithms, even with an emphasis on understanding and the use of materials such as multi-attribute blocks (MAB), often caused great difficulties for some children. As a result of analysing a wide range of samples of children's informal and formal use of pencil and paper for calculating, a six-step structure for moving from mental computation to informal written computation was developed and used by teachers as a scaffold. Table 1 shows the six-step process.

Figure 1 shows an example of a child's correct explanation for the calculation of 35 + 28.

Table 1. Six-step process for moving from mental to informal written computation

Step	Process
1	Strengthen children's mental computation with two digit numbers.
2	Encourage children to explain their methods using pencil and paper.
3	Compare, discuss and so refine their written explanations.
4	Strengthen this method with further calculations of similar difficulty
5	Extend its use by adapting it to calculate more difficult examples
6	Consolidate it as an 'understood, secure written method'.

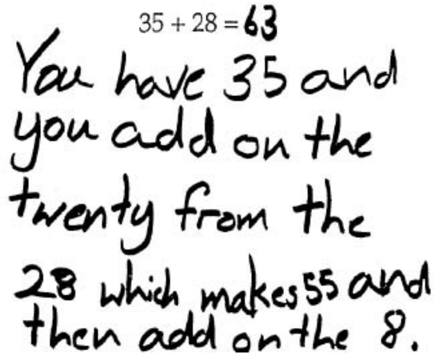

Figure 1. An example of a child's informal written computation.

Children were encouraged to work on their explanations with the help of their teacher. Teachers used three assessment criteria for the children's written explanations, based on those proposed by Campbell, Rowan & Suarez (1998): efficiency (is it a concise and effective method?), validity (is it mathematically sound?), and generalisability (could it be used on a wide range of computations, especially with larger numbers?). This framework proved invaluable in providing teachers with a clear sequence of goals.

Step 3 is critical in assisting children to move towards more efficient, valid and generalisable written explanations. Figures 2, 3 and 4 illustrate one child's progress to formal representation. The misunderstanding of the use of the 'equals' sign displayed in Figure 2 illustrates the need for teachers to check the validity of children's written explanations.

Most teachers responded positively to the program, as demonstrated by the following three responses:

> … I feel like I can finally do something well because I'm seeing results and I'm seeing that enthusiasm from the children — it's just exciting when they're a step ahead of me. I'll be thinking, 'I hope they come up with this strategy today,' or, 'I hope they'll see this,' and they do.

> Children are much more confident in solving problems and with their understanding of numbers/place value. I have seen a huge jump in the children's confidence with numbers/problems.

> Previously I taught all the algorithms to brighter Grade 2s and Grade 3s. I believed that I was teaching for understanding but now I don't think I was. Having taught informal strategies to my class I can see much greater understanding in what the children are doing. Now I don't think they necessarily need algorithms to solve problems, but strategies which work for the individual.

Teachers reported growth in the children's confidence:

> A new way of thinking … I'm trying to get them to understand — I think we're nearly there — that we're away from

thinking, 'I've got to do it the teacher's way,' to, 'The teacher's way is one way, and this is one way, and that's one way,' … and they're also getting confident enough now to know that, 'My way is right'.

Because I say to them, 'It doesn't matter if it's right or wrong, tell me how you did it,' they're more willing to have a go — the slower ones, I think are more willing to have a go at it. The pressure's off, it doesn't matter if it's wrong. Whereas if you gave them the normal way — I'm talking about two-digit addition here — they'd get confused with the carrying the tens and things.

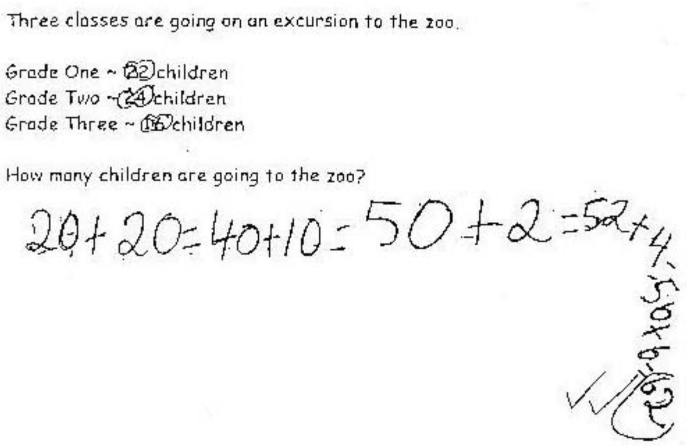

Figure2. A child's written explanation of his mental calculation method.

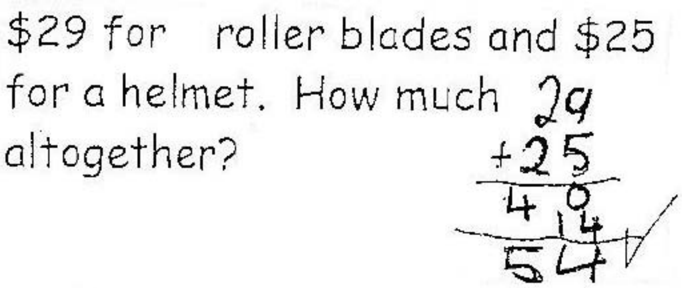

Figure 3. The same child recording a similar calculation after 'conferencing'.

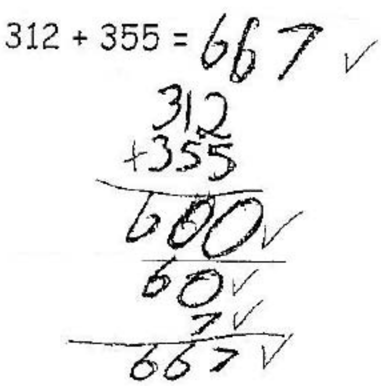

Figure 4. The same child using a similar method to compute a more difficult calculation.

Questioned about their attitude to the introduction of formal algorithms for addition, most teachers believed that Years 4 or 5 were appropriate:

> Not before [Year] 5. Students are able to use their own written strategies which make sense to them.
>
> I think by about [Year] 4, children should be introduced to the standard algorithms so that if they choose to use this method they can. But I believe that they need a strong understanding of mental strategies because they will need to be able to do things in their heads as well. Furthermore using informal methods often makes more sense to the children so I would encourage them to use them if they choose best.

Conclusion

The project produced a number of significant findings. All teachers in the project agreed that the concentration on mental computation had greatly increased children's competence and confidence in handling numbers and in understanding place value. Most schools saw Prep or Kindergarten as the best time to start this approach for the majority of children.

Whereas most teachers previously would have advocated the introduction of standard written algorithms from Years 1 or 2, they now suggested Year 4 as more appropriate. They recognised that the increased understanding of numbers and place value acquired through concentrating on mental computation provided a much more secure basis for a later introduction of the written algorithms.

All teachers agreed on the benefits of developing informal written methods as a bridge between mental and formal written methods. They stated that it helped children develop 'understood' ways of dealing with larger numbers, that seeing their thinking strategies in writing helped them to clarify their mental strategies, and that the presence of written work helped teachers to 'see' children's thinking and to work on misunderstandings.

Reference

Campbell, P., Rowan, T. & Suarez, A. (1998). What criteria for student-invented algorithms? In L. Morrow & M. Kenney (Eds), *The Teaching and Learning of Algorithms in School Mathematics*, pp. 49–55. Reston, VA: NCTM.

Further information

For a copy of the *Developing Computation* teacher's booklet, phone (03) 6233 7033 or email denise.neal@education.tas.gov.au.

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